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Rosenthal et al.

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(54) # COMPUTER ASSISTED ANSWERING BOOLEAN QUESTIONS WITH EVIDENCE

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G06F 40/30	(2020.01)

(52) **U.S. Cl.**
CPC ***G06F 40/40*** (2020.01); ***G06F 40/20*** (2020.01); *G06F 40/30* (2020.01)

(58) **Field of Classification Search**
CPC G06F 40/30; G06F 40/20; G06F 40/40
See application file for complete search history.

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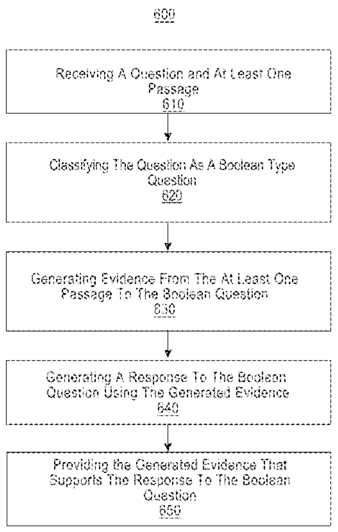
(57) **ABSTRACT**

A method of using a computing device using natural language software to respond to a Boolean question is presented. The method includes receiving, by a computing device, a question and at least one passage. The computing device classifies the question as a Boolean type question. The computing device generates evidence from the at least one passage to the Boolean question. The computing device generates a response to the Boolean question using the generated evidence. The computing device provides the generated evidence that supports the response to the Boolean question.

11 Claims, 11 Drawing Sheets


600
Receiving A Question and At Least One Passage
610
Classifying The Question As A Boolean Type Question
620
Generating Evidence From The At Least One Passage To The Boolean Question
630
Generating A Response To The Boolean Question Using The Generated Evidence
640
Providing the Generated Evidence That Supports The Response To The Boolean Question
650

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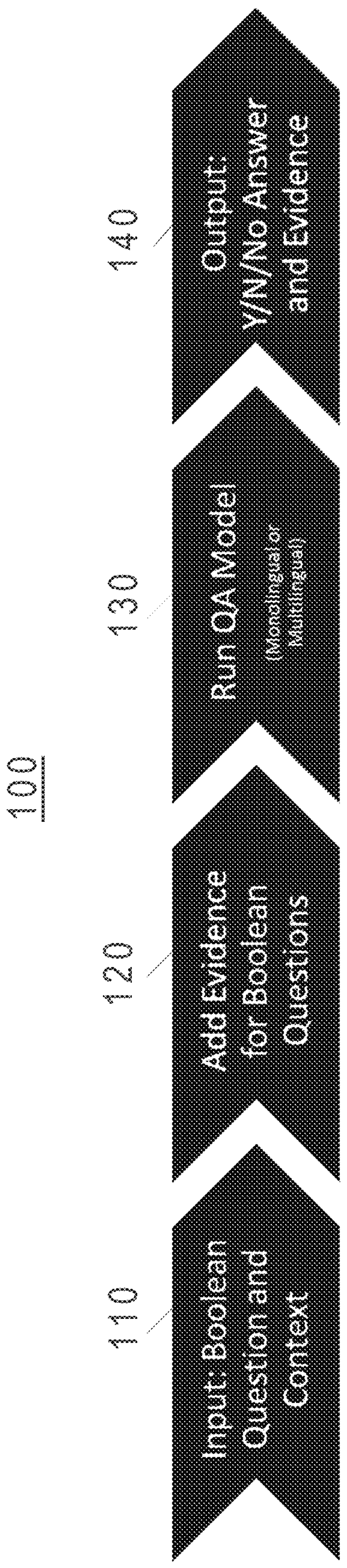

100
110
Input: Boolean Question and Context
120
Add Evidence for Boolean Questions
130
Run QA Model
(Monolingual or Multilingual)
140
Output: Y/N/No Answer and Evidence

FIG. 1

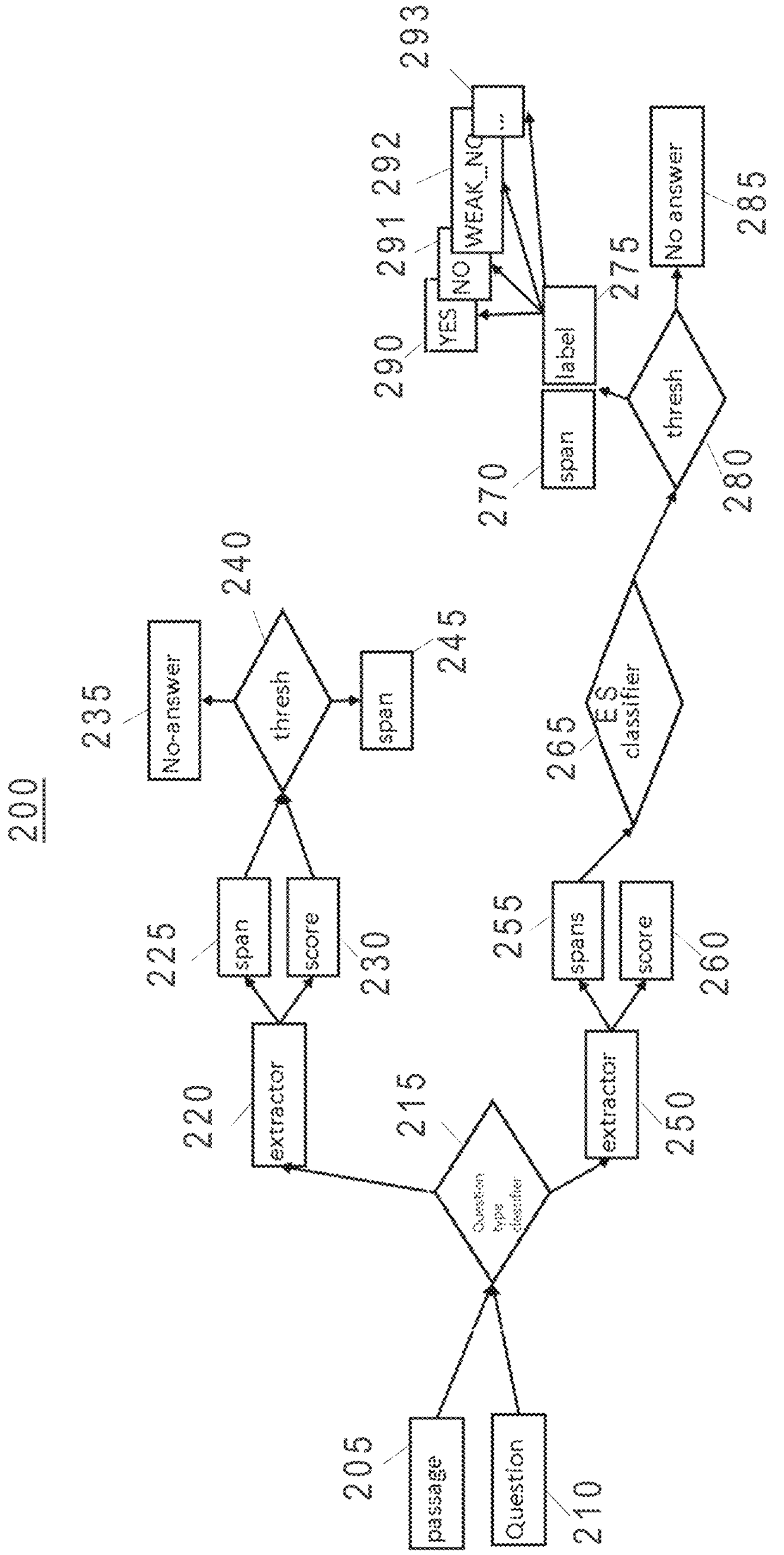
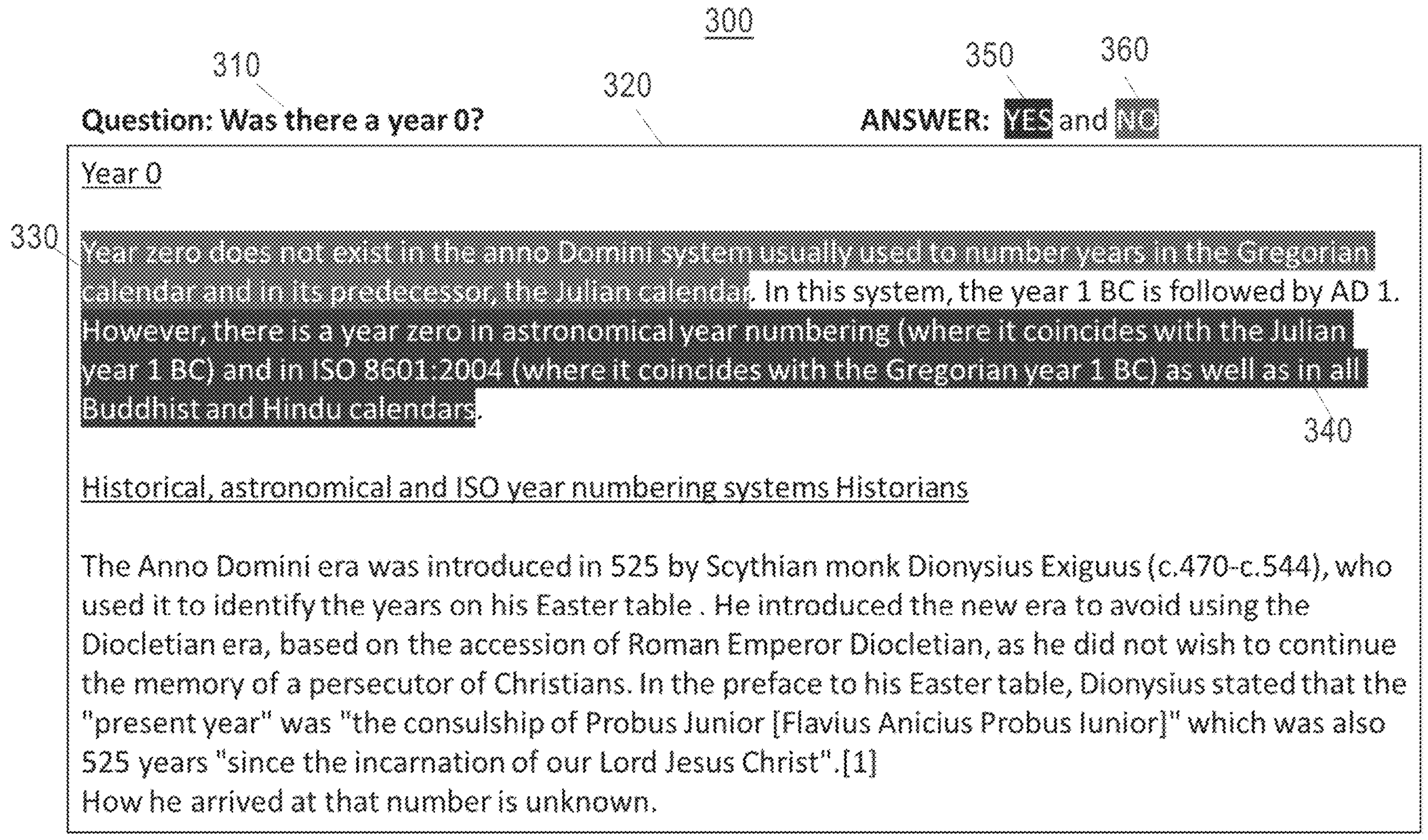

200
205
passage
210
Question
215
Question type classifier
220
extractor
225
span
230
score
235
No-answer
240
thresh
245
span
250
extractor
255
spans
260
score
265
ES classifier
270
span
275
label
280
thresh
285
No answer
290
YES
291
NO
292
WEAK_NO
293
...

FIG. 2



Question: Was there a year 0?

ANSWER: YES and NO

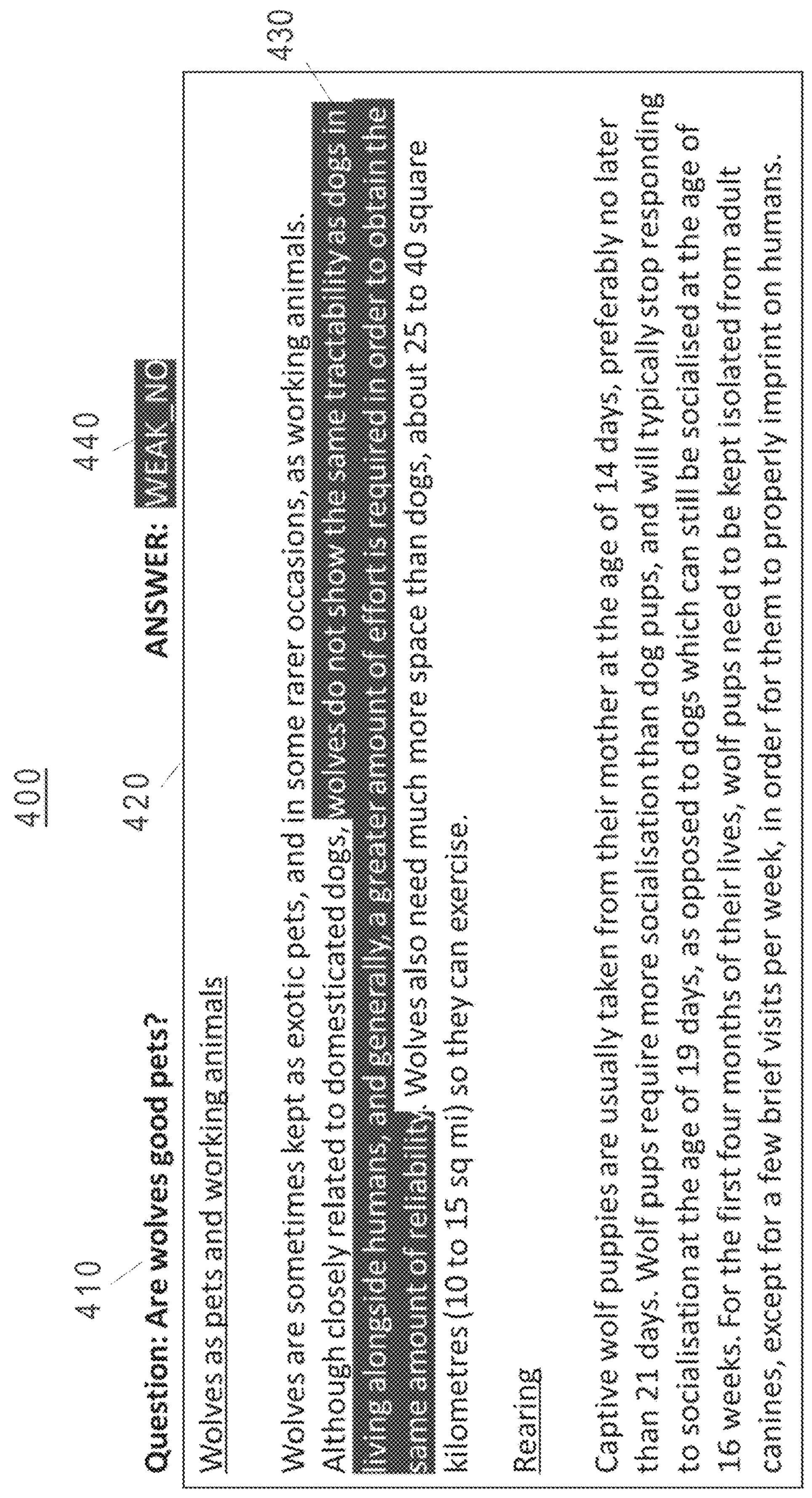
Year 0

Year zero does not exist in the anno Domini system usually used to number years in the Gregorian calendar and in its predecessor, the Julian calendar. In this system, the year 1 BC is followed by AD 1. However, there is a year zero in astronomical year numbering (where it coincides with the Julian year 1 BC) and in ISO 8601:2004 (where it coincides with the Gregorian year 1 BC) as well as in all Buddhist and Hindu calendars.

Historical, astronomical and ISO year numbering systems Historians

The Anno Domini era was introduced in 525 by Scythian monk Dionysius Exiguus (c.470-c.544), who used it to identify the years on his Easter table . He introduced the new era to avoid using the Diocletian era, based on the accession of Roman Emperor Diocletian, as he did not wish to continue the memory of a persecutor of Christians. In the preface to his Easter table, Dionysius stated that the "present year" was "the consulship of Probus Junior [Flavius Anicius Probus Iunior]" which was also 525 years "since the incarnation of our Lord Jesus Christ".[1]
How he arrived at that number is unknown.

FIG. 3



Question: Are wolves good pets? **ANSWER:** WEAK_NO

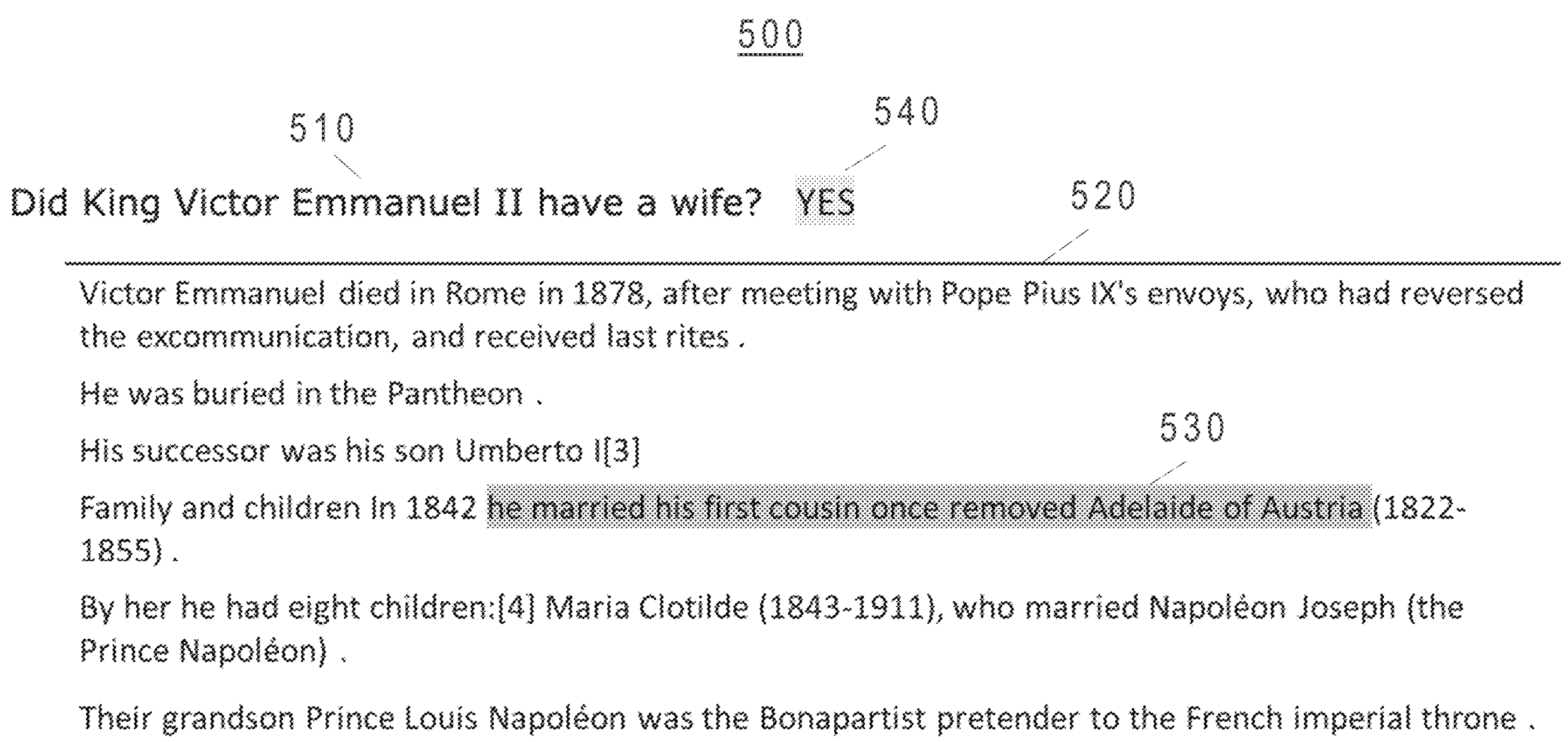
Wolves as pets and working animals

Wolves are sometimes kept as exotic pets, and in some rarer occasions, as working animals. Although closely related to domesticated dogs, wolves do not show the same tractability as dogs in living alongside humans, and generally, a greater amount of effort is required in order to obtain the same amount of reliability. Wolves also need much more space than dogs, about 25 to 40 square kilometres (10 to 15 sq mi) so they can exercise.

Rearing

Captive wolf puppies are usually taken from their mother at the age of 14 days, preferably no later than 21 days. Wolf pups require more socialisation than dog pups, and will typically stop responding to socialisation at the age of 19 days, as opposed to dogs which can still be socialised at the age of 16 weeks. For the first four months of their lives, wolf pups need to be kept isolated from adult canines, except for a few brief visits per week, in order for them to properly imprint on humans.

FIG. 4



Did King Victor Emmanuel II have a wife? YES

Victor Emmanuel died in Rome in 1878, after meeting with Pope Pius IX's envoys, who had reversed the excommunication, and received last rites .

He was buried in the Pantheon .

His successor was his son Umberto I[3]

Family and children In 1842 he married his first cousin once removed Adelaide of Austria (1822-1855) .

By her he had eight children:[4] Maria Clotilde (1843-1911), who married Napoléon Joseph (the Prince Napoléon) .

Their grandson Prince Louis Napoléon was the Bonapartist pretender to the French imperial throne .

FIG. 5

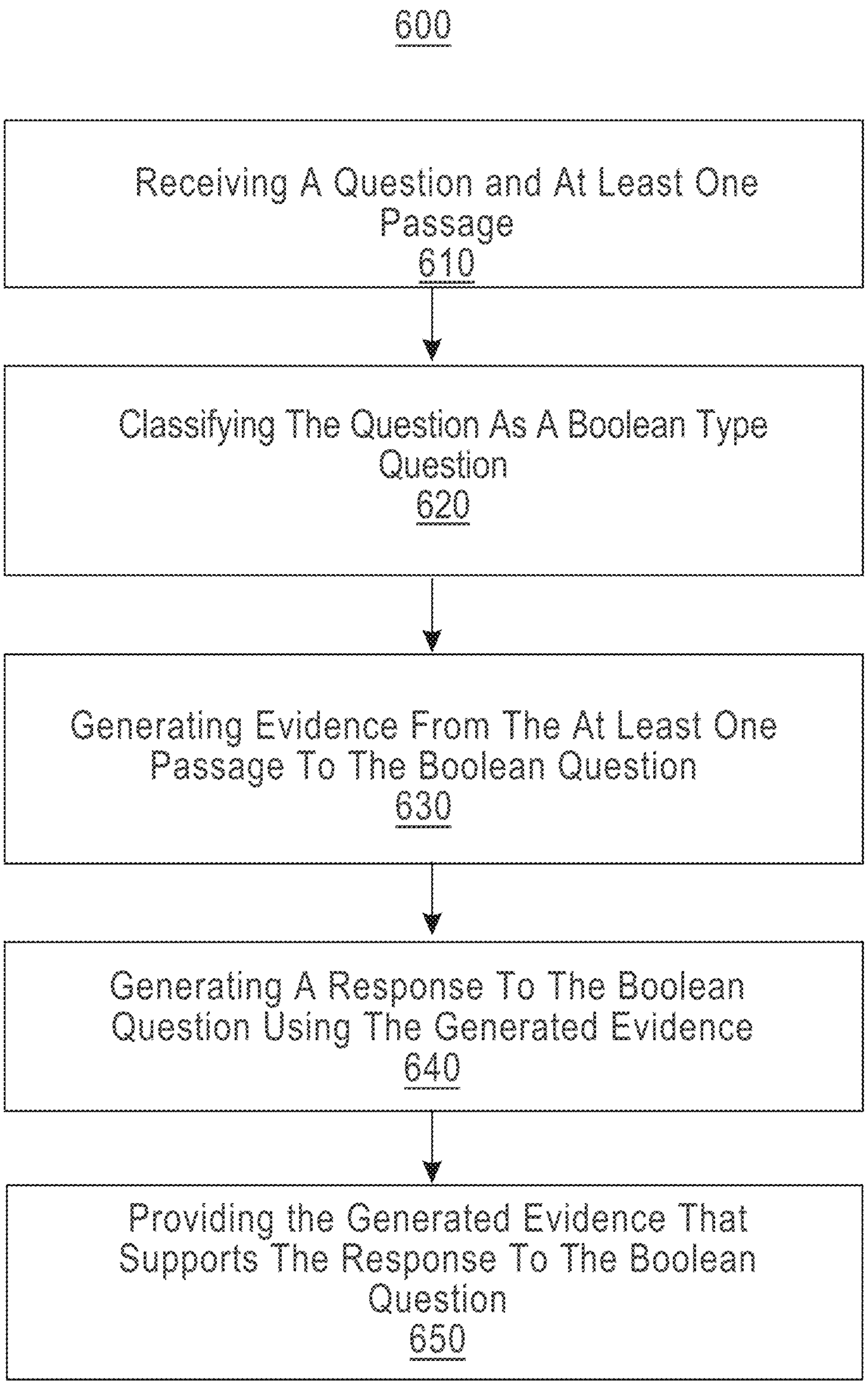

600
Receiving A Question and At Least One Passage
610
Classifying The Question As A Boolean Type Question
620
Generating Evidence From The At Least One Passage To The Boolean Question
630
Generating A Response To The Boolean Question Using The Generated Evidence
640
Providing the Generated Evidence That Supports The Response To The Boolean Question
650

FIG. 6

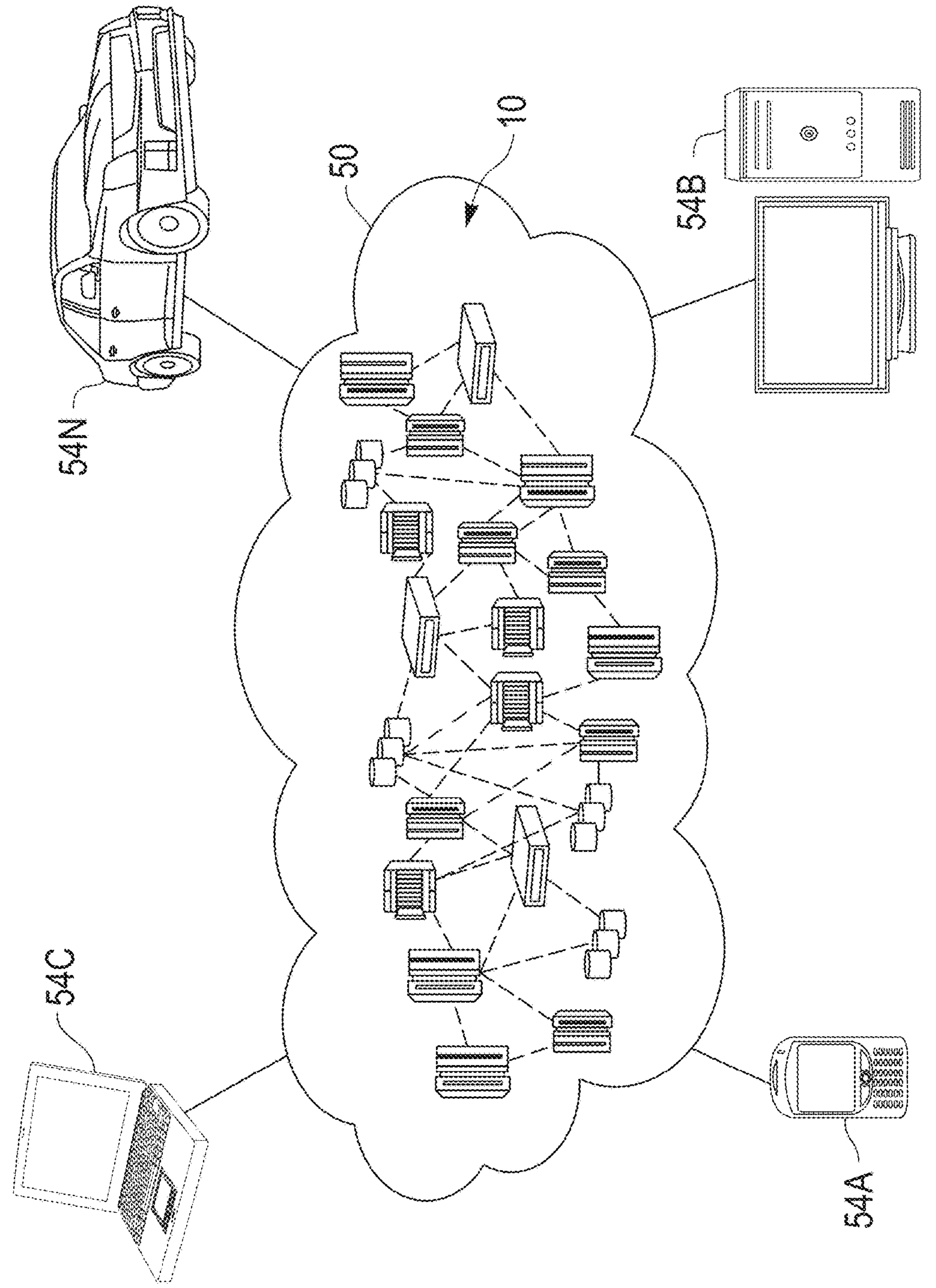


FIG. 7

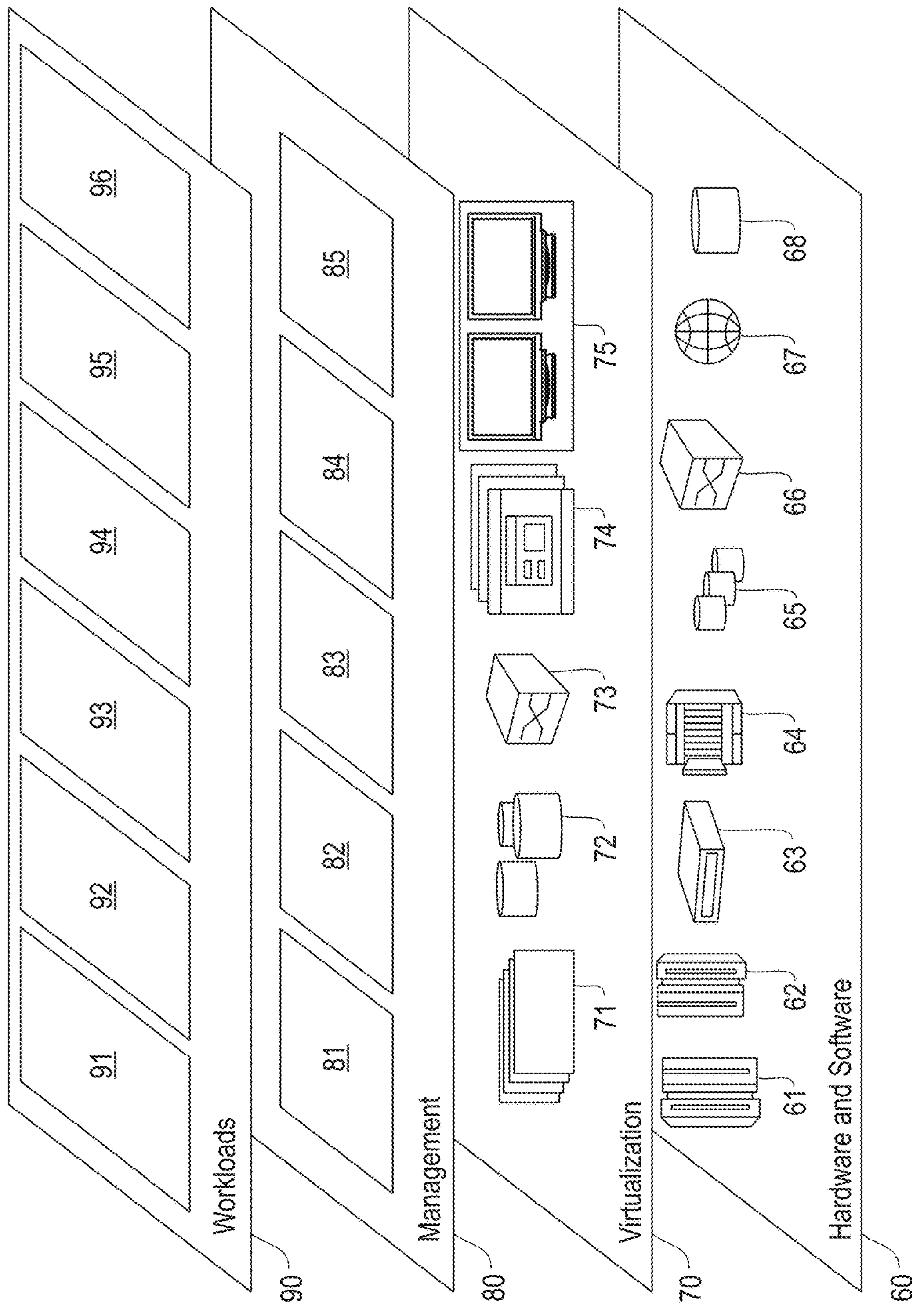
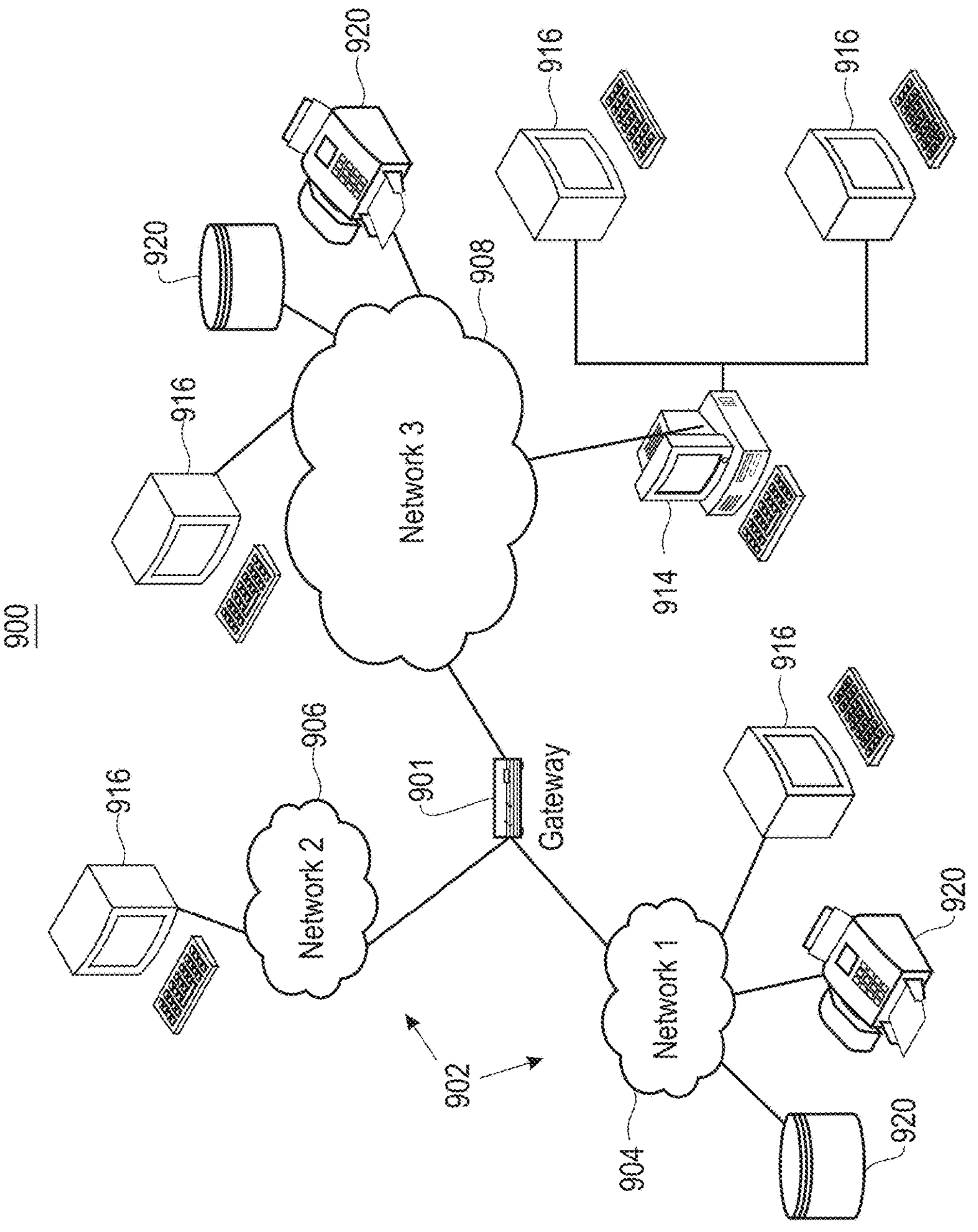

91
92
93
94
95
96
Workloads
90
81
82
83
84
85
Management
80
71
72
73
74
75
Virtualization
70
61
62
63
64
65
66
67
68
Hardware and Software
60

FIG. 8


900
902
Network 1
904
Network 2
906
Gateway
901
Network 3
908
914
916
916
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916
920
920
920
920

FIG. 9

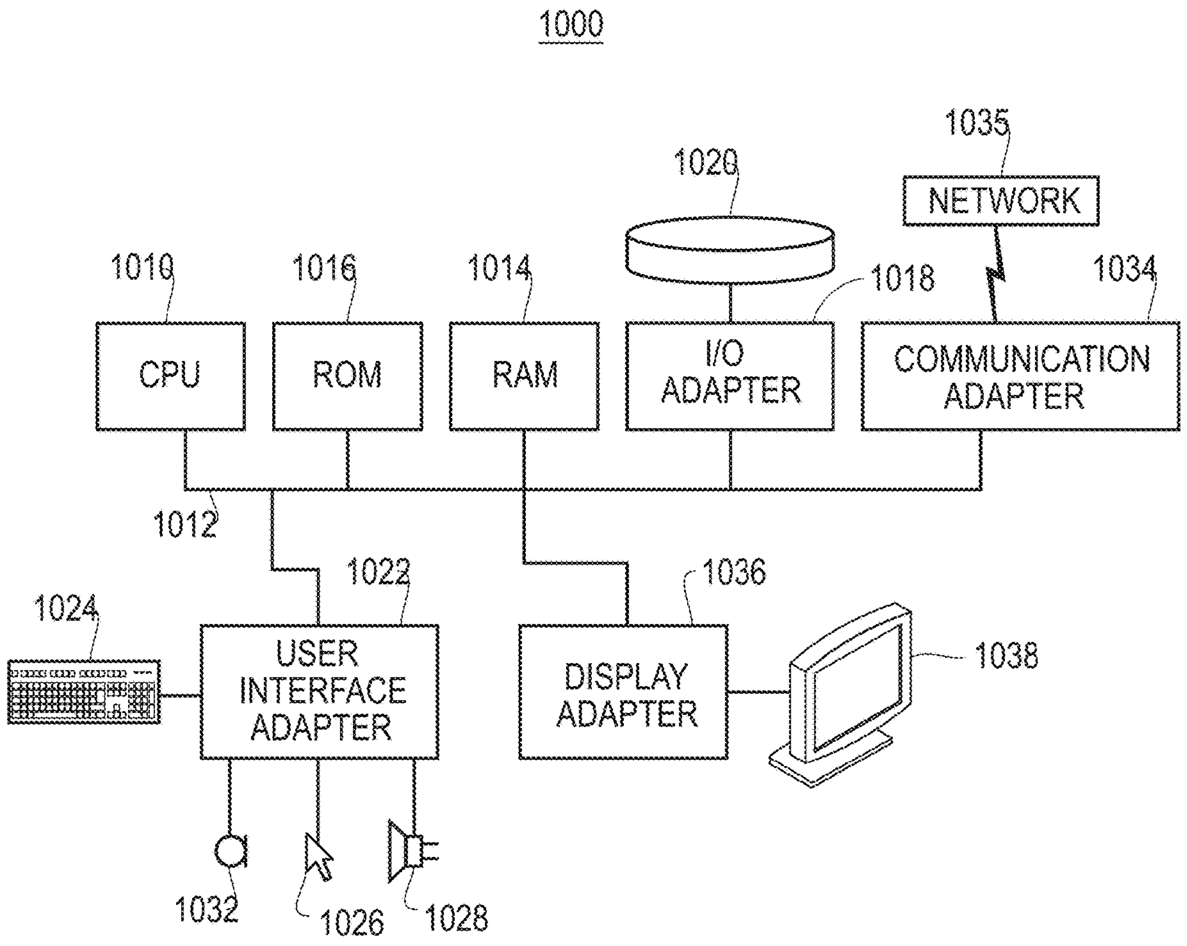
1000
1035
NETWORK
1020
1010
1016
1014
1018
1034
CPU
ROM
RAM
I/O ADAPTER
COMMUNICATION ADAPTER
1012
1022
1036
1024
USER INTERFACE ADAPTER
DISPLAY ADAPTER
1038
1032
1026
1028

FIG. 10

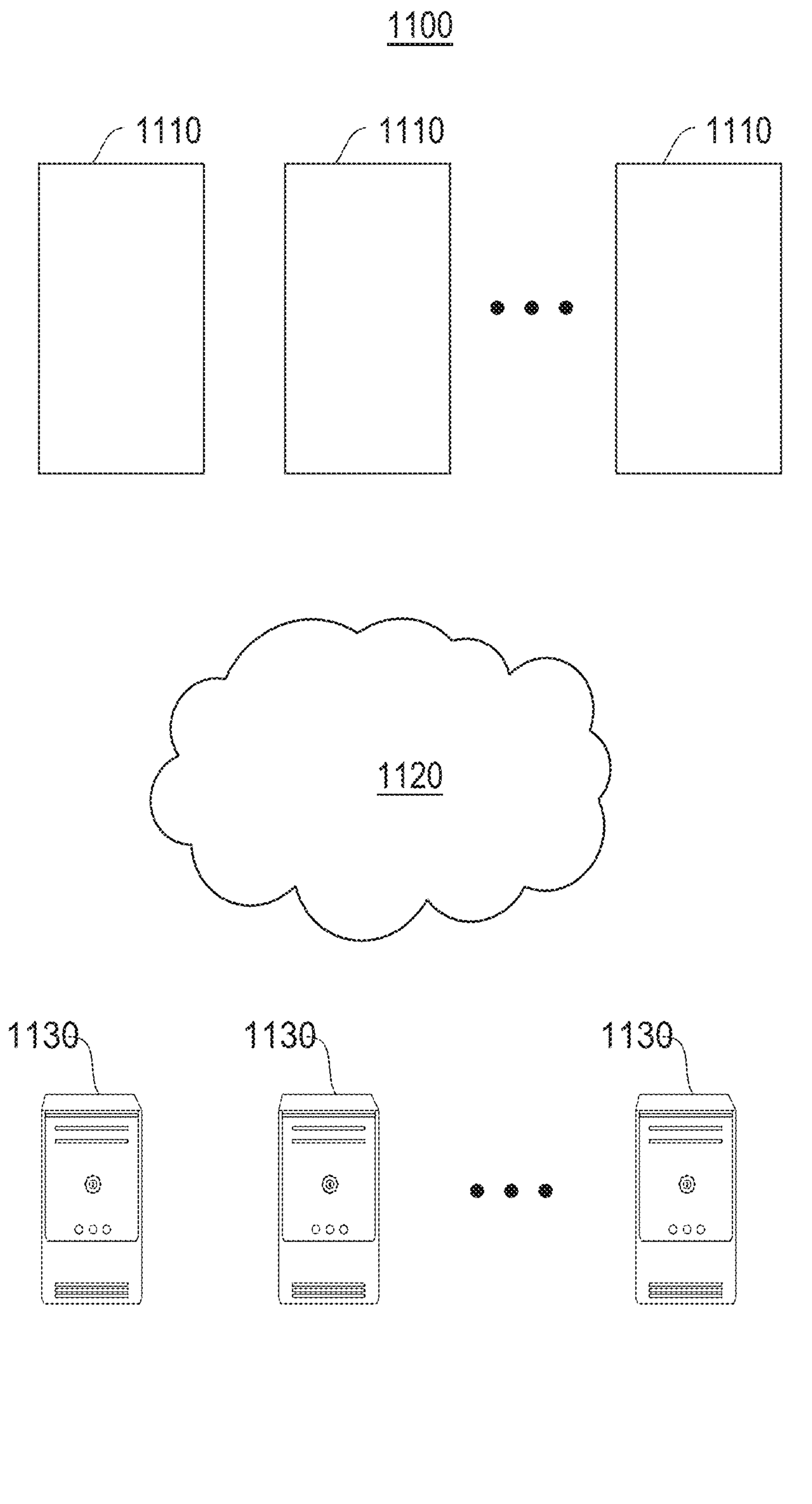

FIG. 11

COMPUTER ASSISTED ANSWERING BOOLEAN QUESTIONS WITH EVIDENCE

BACKGROUND

The field of embodiments of the present invention relates to use of a computing device using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions in a question answering (QA) system.

QA systems are an important tool used by people seeking answers. In factoid question answering, there is a short answer to the question. In some cases, the answer is Boolean. Existing QA systems expect Boolean questions to be answered with Yes, No, or No Answer without providing justification. Further, a simple Yes/No is not always appropriate.

SUMMARY

Embodiments relate to use of a computing device using natural language software to respond to a Boolean question. One embodiment provides a method of using a computing device using natural language software to respond to a Boolean question is presented. The method includes receiving, by a computing device, a question and at least one passage. The computing device classifies the question as a Boolean type question. The computing device generates evidence from the at least one passage to the Boolean question. The computing device generates a response to the Boolean question from the generated evidence. The computing device provides the generated evidence that supports the response to the Boolean question. Some features contribute to the advantage of automatically providing evidence demarcation, and more fine-grained answers to Boolean questions in a QA system. This provides the user with a better understanding of the answer to the question. Other features provide that the Boolean questions and answers can be in one or more languages, and need not be the same language. Further features provide that multiple answers, even if conflicting, may be in one or more passages in a corpus.

One or more of the following features may be included. In some embodiments, the method may further include the feature that the classifying employs a question type classifier to determine the question type.

In some embodiments, the method may additionally include the feature that the response is a single Boolean type of answer. Another feature that may be included is that the response is more than one Boolean type of answer.

In one or more embodiments, the method may further include that the response is a fine-grained Boolean type of answer, and the fine-grained Boolean type of answer is labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer or a scaled type of answer.

In some embodiments, the method may include that the generated evidence that supports the response is indicated by demarcating the generated evidence in the at least one passage.

In some embodiments, the method may include that the generated evidence comprises text-based evidence in one or more languages.

These and other features, aspects and advantages of the present embodiments will become understood with reference to the following description, appended claims and accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a Boolean question answering (QA) pipeline, according to one embodiment;

FIG. **2** illustrates a machine reading comprehension (MRC) pipeline with Boolean questions, according to one embodiment;

FIG. **3** illustrates an example display of evidence in response to a proposed Boolean question, according to one embodiment;

FIG. **4** illustrates another example display of evidence in response to a proposed Boolean question, according to one embodiment;

FIG. **5** illustrates yet another example display of evidence in response to a proposed Boolean question, according to one embodiment;

FIG. **6** illustrates a process for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to an embodiment;

FIG. **7** depicts a cloud computing environment, according to an embodiment;

FIG. **8** depicts a set of abstraction model layers, according to an embodiment;

FIG. **9** is a network architecture of a system for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to an embodiment;

FIG. **10** shows a representative hardware environment that may be associated with the servers and/or clients of FIG. **7**, according to an embodiment; and

FIG. **11** is a block diagram illustrating a distributed system for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to one embodiment.

DETAILED DESCRIPTION

The descriptions of the various embodiments have been presented for purposes of illustration, but are not intended to be exhaustive or limited to the embodiments disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the described embodiments. The terminology used herein was chosen to best explain the principles of the embodiments, the practical application or technical improvement over technologies found in the marketplace, or to enable others of ordinary skill in the art to understand the embodiments disclosed herein.

Embodiments relate to use of a computing device using natural language software to respond to a Boolean question. One embodiment provides a method of using a computing device using natural language software to respond to a Boolean question is presented. The method includes receiving, by a computing device, a question and at least one passage. The computing device classifies the question as a Boolean type question. The computing device generates evidence from the at least one passage to the Boolean question. The computing device generates a response to the Boolean question using the generated evidence. The computing device provides the generated evidence that supports the response to the Boolean question. Some features contribute to the advantage of automatically providing evidence demarcation, and more fine-grained answers to Boolean questions in a QA system. This provides the user with a better understanding of the answer to the question. Other features provide that the Boolean questions and answers can be in one or more languages, and need not be the same language. Further features provide that multiple answers, even if conflicting, may be in one or more passages in a corpus.

In some embodiments, the method may further include the feature that the classifying employs a question type classifier to determine the question type.

In some embodiments, the method may additionally include the feature that the response is a single Boolean type of answer. Another feature that may be included is that the response is more than one Boolean type of answer.

In one or more embodiments, the method may further include that the response is a fine-grained Boolean type of answer, and the fine-grained Boolean type of answer is labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer or a scaled type of answer.

In some embodiments, the method may include that the generated evidence that supports the response is indicated by demarcating the generated evidence in the at least one passage.

In some embodiments, the method may include that the generated evidence comprises text-based evidence in one or more languages.

FIG. **1** illustrates a Boolean question answering (QA) pipeline **100**, according to one embodiment. In some embodiments, the pipeline **100** is an MRC pipeline. In one embodiment, in block **110**, a Boolean question and context are received by a computing device using natural language software (e.g., conventional natural language understanding software, etc.) of a QA system. In block **120**, evidence is added for Boolean questions, such as information from a corpus or collection of documents, publications, internal documents, etc., with text that relates to the Boolean question (e.g., found through a conventional natural language search application, etc.). In block **130**, a QA model (e.g., monolingual or multilingual) is executed. In block **140**, the output is generated from the QA model with a Y(es), N(o), No answer, Yes and No, weak-No, weak-Yes, scaled, etc. along with evidence (e.g., textual information) supporting the output. In one or more embodiments, the QA model has the ability for conflicting answers in a single passage to be highlighted for the user. The use of evidence for Boolean questions improves the QA system as the user has the text automatically displayed and highlighted to provide more support for the Boolean of fine-grained answers. This also provides the user with a better understanding of the answer to the question.

FIG. **2** illustrates a machine reading comprehension (MRC) pipeline **200** with Boolean questions, according to one embodiment. In block **210** a textual (which may be in natural language or converted from voice to natural language using a conventional application, etc.) question is provided, such as by obtaining from another passage, obtained from a computing device or memory from an initiating user, resulted from a search query, etc. In block **205**, one or more supporting passages are provided based on one or more topics or words obtained from the question **210**, a search query (e.g., using a search engine), etc. The one or more passages may be obtained from one or more documents, other natural language sources, such as emails, articles, etc.) based on elements in the question. In block **215**, a question type classifier uses natural language understanding (NLU) that classifies a type of question to provide information addressing whether the question is of a Boolean type or not. If the question type classifier determines the question has a traditional answer (e.g., Who is the president of the United States?) or is selected to have such an answer, the pipeline **200** proceeds to block **220** where an extractor (e.g., a conventional text-based extractor, etc.) is employed to extract portions from the supporting passage(s) **205** based on the type of question. In block **225**, pipeline **200** sets the answer span over the passage for the question text (if appropriate), and sets any other features in the extracted text. Note that there may be multiple instances of these. In block **230**, a score that was determined by the extractor in block **220** for the span of the supporting passage(s) is stored in a memory device. The extractor in block **220** may implement scoring via a simple term match score implementing executable instructions for counting the number of terms that match; textual alignment implementing executable instructions for determining if words appear in the same or similar order with a similar distance between them so they are not separated much (aligned) that is advantageous to find a quotation to find quotes, for example, an alignment may be performed to obtain the best result; and, a deeper analysis implementing executable instructions for determining the meaning of the passages/question (i.e., lexical and/or semantic relations). Each of these analyses produces a score. In one or more embodiments, the span from block **225** and the score from block **230** are used in block **240** to determine whether a threshold is exceeded or not. If the threshold is not met, the result in block **235** is No-answer. If the threshold is met or exceeded, in block **245** a span from the passage supporting the non-boolean answer is output.

If the question type classifier in block **215** determines the question is Boolean (such as "Is Joe Biden the president of the United States?), or is selected to be a Boolean type question, the pipeline **200** proceeds to block **250** where an extractor (e.g., a conventional text-based extractor, etc.) is employed to extract portions from the supporting passage(s) **205** based on the type of question. In block **255**, pipeline **200** sets the span over the question text (if appropriate), and sets any other features in the extracted text. Note that there may be multiple instances of these. In block **260**, a score is determined for the span of the supporting passage(s) using a conventional scoring application or algorithm. In block **265**, the evidence span classifier determines the answer (e.g., weak No, weak Yes, No, Yes, Yes and No, etc.) to a Boolean type question. In block **280**, it is determined whether the answer has a value that meets (e.g., equal to or greater) a threshold or not (e.g., less than the threshold) for having an answer (i.e., Yes and No, weak-No, weak-Yes, scaled, etc.). If it is determined there is no answer, the pipeline **200** proceeds to block **285** where the output is no answer. Otherwise, the pipeline **200** proceeds to block **270** where the span of the passages for the answer is set. In some embodiments, the pipeline **200** provides a label **275** for fine-grained short answer(s) besides Yes **290** and No **291** are provided as output, which may include weak-No **292**, or others **293**, such as weak-Yes. Alternatively, a scale of 1-n can be used instead of short answers, where **1** may indicate a strong No and n would indicate a strong Yes. For each short answer, the pipeline **200** demarcates or highlights the evidence span **270** in the passage that explains the reasoning for the label generated in block **275** for that short answer, and each short answer's evidence span may have a different label. In addition to highlighting the evidence span in block **270** co-reference resolution may be applied to highlight the appropriate entity. The output evidence span from block **270** is highlighted as justification for the output short answer(s). In some embodiments, the highlighting may include colors (e.g., fixed, or selectable), underlining, other markings (e.g., blurring portions of text while making evidence readable, larger font, bring to front, place behind, etc.). The Boolean questions and answers may be in one or more languages, and they need not be the same language. Multiple answers may be in one or more passages in a corpus, depository, etc.

Unlike conventional systems that may have the ability to only output some evidence for Boolean type questions without labeling an answer, those systems do not automatically highlight supporting passages of the evidence for multiple answers (e.g., Yes and No), they do not provide an answer with polarity that is fine-grained, and they do not even handle cases where there can be both Yes and No answers in a single passage or multiple passages. Further distinguishable from conventional systems, one or more embodiments classify questions as Boolean and non-Boolean, and display highlighted supporting evidence of for Boolean questions. Some embodiments capture use cases where Boolean questions may not have a straight-forward Yes or No answer; and these embodiments also work with one or more different languages. Using a question type classifier **215** to identify which questions are Boolean is more reliable than conventional systems and also avoids giving a YES/NO answer when the question is not Boolean.

FIG. **3** illustrates an example display **300** of evidence **320** in response to a proposed Boolean question **310**, according to one embodiment. As shown, the support evidence **330** and **340** in the contextual surrounding passages **320** are indicated in this example as highlighting, and have different highlighting from one another. Support evidence **330** is associated with the output answer No **360**, and support evidence **340** is associated with output answer Yes **350**. The contextual surrounding passage **320** is also displayed for context. The output answers Yes **350** and No **360** alerts the viewer that there are multiple answers to the Boolean question **310** labeled by block **275** (FIG. **2**) as Yes and No, there is supporting evidence **330** and **340** for answers Yes **350** and No **360**, which are each highlighted in the example display **300** the same as the respective supporting evidences **330** and **340**.

FIG. **4** illustrates another example display **400** of evidence **420** in response to a proposed Boolean question **410**, according to one embodiment. In this example display **400**, the supporting evidence **430** is highlighted and associated with the answer Weak-No **440**. The answer Weak-No **440** alerts the viewer that the answer to the Boolean question **410** is likely No, but that answer does not have enough weight over the threshold **280** (FIG. **2**) to be labeled in block **275** (FIG. **2**) as a No, so block **275** labeled the output as Weak-No **292** for the result output answer Weak-No **440**, which is highlighted the same in the example display **400** as the support evidence **430**.

FIG. **5** illustrates yet another example display **500** of evidence **520** in response to a proposed Boolean question **510**, according to one embodiment. In this example display **500**, the supporting evidence **530** is highlighted and associated with the answer Yes **540**. The answer Yes **540** alerts the viewer that the answer to the Boolean question had enough weight over the threshold **280** (FIG. **2**) to be labeled in block **275** (FIG. **2**) as a Yes **290**, so block **275** labeled the output as Yes **540** for the result output answer, which is highlighted the same in the example display **500** as the supporting evidence **530**.

FIG. **6** illustrates a process **600** for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to an embodiment. In block **610**, process **600** provides receiving, by a computing device (e.g., from computing node **10**, FIG. **7**, hardware and software layer **60**, FIG. **8**, processing system **900**, FIG. **9**, system **1000**, FIG. **10**, system **1100**, FIG. **11**, etc.), a question (e.g., a simple question, a Boolean question, etc.) and at least one passage. In block **620**, process **600** provides classifying, by the computing device, the question as a Boolean type question. In block **630**, process **600** provides generating, by the computing device, evidence from the at least one passage. In block **640**, process **600** provides generating, by the computing device, a response (e.g., Yes, No, Yes and No, weak-Yes, weak-No, 1-n (n is an integer where the higher the n, the stronger the answer as Yes or No, depending on implementation) to the Boolean question using the generated evidence. In block **650**, process **600** includes providing, by the computing device, the generated evidence (e.g., textual passage(s)) and response that supports the response to the Boolean question.

In some embodiments, process **600** provides the feature that the classifying employs a question type classifier to determine the question type (e.g., Boolean, non-Boolean, etc.). In one or more embodiments, process **600** may include that the response is a single Boolean type of answer (e.g., Yes, No).

In some embodiments, process **600** provides the feature that the response is more than one Boolean type of answer (e.g., Yes and No). In one or more embodiments, process **600** may include that the response is a fine-grained Boolean type of answer, and the fine-grained Boolean type of answer is labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer or a scaled type (e.g., 1-n) of answer.

In one or more embodiments, process **600** provides that the generated evidence that supports the response is indicated by demarcating (e.g., include colors (e.g., fixed, or selectable), underlining, other markings (e.g., blurring portions of text while making evidence readable, larger font, bring to front, place behind, etc.)), the generated evidence in the at least one passage.

In some embodiments, process **600** provides that the generated evidence comprises text-based evidence in one or more languages.

It is understood in advance that although this disclosure includes a detailed description of cloud computing, implementation of the teachings recited herein are not limited to a cloud computing environment. Rather, embodiments of the present embodiments are capable of being implemented in conjunction with any other type of computing environment now known or later developed.

Cloud computing is a model of service delivery for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, network bandwidth, servers, processing, memory, storage, applications, virtual machines (VMs), and services) that can be rapidly provisioned and released with minimal management effort or interaction with a provider of the service. This cloud model may include at least five characteristics, at least three service models, and at least four deployment models.

Characteristics are as follows:

On-demand self-service: a cloud consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed and automatically, without requiring human interaction with the service's provider.

Broad network access: capabilities are available over a network and accessed through standard mechanisms that promote use by heterogeneous, thin or thick client platforms (e.g., mobile phones, laptops, and PDAs).

Resource pooling: the provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to demand. There is a sense of location independence in that the consumer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or data center).

Rapid elasticity: capabilities can be rapidly and elastically provisioned and, in some cases, automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.

Measured service: cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active consumer accounts). Resource usage can be monitored, controlled, and reported, thereby providing transparency for both the provider and consumer of the utilized service.

Service Models are as follows:

Software as a Service (SaaS): the capability provided to the consumer is the ability to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface, such as a web browser (e.g., web-based email). The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited consumer-specific application configuration settings.

Platform as a Service (PaaS): the capability provided to the consumer is the ability to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure including networks, servers, operating systems, or storage, but has control over the deployed applications and possibly application-hosting environment configurations.

Infrastructure as a Service (IaaS): the capability provided to the consumer is the ability to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components (e.g., host firewalls).

Deployment Models are as follows:

Private cloud: the cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on-premises or off-premises.

Community cloud: the cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on-premises or off-premises.

Public cloud: the cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

Hybrid cloud: the cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

A cloud computing environment is a service oriented with a focus on statelessness, low coupling, modularity, and semantic interoperability. At the heart of cloud computing is an infrastructure comprising a network of interconnected nodes.

Referring now to FIG. **7** an illustrative cloud computing environment **50** is depicted. As shown, cloud computing environment **50** comprises one or more cloud computing nodes **10** with which local computing devices used by cloud consumers, such as, for example, personal digital assistant (PDA) or cellular telephone **54**A, desktop computer **54**B, laptop computer **54**C, and/or automobile computer system **54**N may communicate. Nodes **10** may communicate with one another. They may be grouped (not shown) physically or virtually, in one or more networks, such as private, community, public, or hybrid clouds as described hereinabove, or a combination thereof. This allows the cloud computing environment **50** to offer infrastructure, platforms, and/or software as services for which a cloud consumer does not need to maintain resources on a local computing device. It is understood that the types of computing devices **54**A-N shown in FIG. **7** are intended to be illustrative only and that computing nodes **10** and cloud computing environment **50** can communicate with any type of computerized device over any type of network and/or network addressable connection (e.g., using a web browser).

Referring now to FIG. **8**, a set of functional abstraction layers provided by the cloud computing environment **50** (FIG. **7**) is shown. It should be understood in advance that the components, layers, and functions shown in FIG. **8** are intended to be illustrative only and embodiments are not limited thereto. As depicted, the following layers and corresponding functions are provided:

Hardware and software layer **60** includes hardware and software components. Examples of hardware components include: mainframes **61**; RISC (Reduced Instruction Set Computer) architecture based servers **62**; servers **63**; blade servers **64**; storage devices **65**; and networks and networking components **66**. In some embodiments, software components include network application server software **67** and database software **68**.

Virtualization layer **70** provides an abstraction layer from which the following examples of virtual entities may be provided: virtual servers **71**; virtual storage **72**; virtual networks **73**, including virtual private networks; virtual applications and operating systems **74**; and virtual clients **75**.

In one example, a management layer **80** may provide the functions described below. Resource provisioning **81** provides dynamic procurement of computing resources and other resources that are utilized to perform tasks within the cloud computing environment. Metering and pricing **82** provide cost tracking as resources are utilized within the cloud computing environment and billing or invoicing for consumption of these resources. In one example, these resources may comprise application software licenses. Security provides identity verification for cloud consumers and tasks as well as protection for data and other resources. User portal **83** provides access to the cloud computing environment for consumers and system administrators. Service level management **84** provides cloud computing resource allocation and management such that required service levels are met. Service Level Agreement (SLA) planning and fulfillment **85** provide pre-arrangement for, and procurement of, cloud computing resources for which a future requirement is anticipated in accordance with an SLA.

Workloads layer **90** provides examples of functionality for which the cloud computing environment may be utilized. Examples of workloads and functions which may be provided from this layer include: mapping and navigation **91**; software development and lifecycle management **92**; virtual classroom education delivery **93**; data analytics processing **94**; transaction processing **95**; and for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions processing **96** (see, e.g., pipeline **200**, FIG. **2**, process **600**, FIG. **6**, system **900**, FIG. **9**, system **1000**, FIG. **10**, system **1100**, FIG. **11**, etc.). As mentioned above, all of the foregoing examples described with respect to FIG. **8** are illustrative only, and the embodiments are not limited to these examples.

It is reiterated that although this disclosure includes a detailed description on cloud computing, implementation of the teachings recited herein are not limited to a cloud computing environment. Rather, the embodiments may be implemented with any type of clustered computing environment now known or later developed.

FIG. **9** is a network architecture of a system **900** for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to an embodiment. As shown in FIG. **9**, a plurality of remote networks **902** are provided, including a first remote network **904** and a second remote network **906**. A gateway **901** may be coupled between the remote networks **902** and a proximate network **908**. In the context of the present network architecture **900**, the networks **904**, **906** may each take any form including, but not limited to, a LAN, a WAN, such as the Internet, public switched telephone network (PSTN), internal telephone network, etc.

In use, the gateway **901** serves as an entrance point from the remote networks **902** to the proximate network **908**. As such, the gateway **901** may function as a router, which is capable of directing a given packet of data that arrives at the gateway **901**, and a switch, which furnishes the actual path in and out of the gateway **901** for a given packet.

Further included is at least one data server **914** coupled to the proximate network **908**, which is accessible from the remote networks **902** via the gateway **901**. It should be noted that the data server(s) **914** may include any type of computing device/groupware. Coupled to each data server **914** is a plurality of user devices **916**. Such user devices **916** may include a desktop computer, laptop computer, handheld computer, printer, and/or any other type of logic-containing device. It should be noted that a user device **916** may also be directly coupled to any of the networks in some embodiments.

A peripheral **920** or series of peripherals **920**, e.g., facsimile machines, printers, scanners, hard disk drives, networked and/or local storage units or systems, etc., may be coupled to one or more of the networks **904**, **906**, **908**. It should be noted that databases and/or additional components may be utilized with, or integrated into, any type of network element coupled to the networks **904**, **906**, **908**. In the context of the present description, a network element may refer to any component of a network.

According to some approaches, methods and systems described herein may be implemented with and/or on virtual systems and/or systems, which emulate one or more other systems, such as a UNIX® system that emulates an IBMR z/OS environment, a UNIX® system that virtually hosts a

MICROSOFT® WINDOWS® environment, a MICROSOFT® WINDOWS® system that emulates an IBM® z/OS environment, etc. This virtualization and/or emulation may be implemented through the use of VMWARE® software in some embodiments.

FIG. **10** shows a representative hardware system **1000** environment associated with a user device **916** and/or server **914** of FIG. **9**, in accordance with one embodiment. In one example, a hardware configuration includes a workstation having a central processing unit **1010**, such as a microprocessor, and a number of other units interconnected via a system bus **1012**. The workstation shown in FIG. **10** may include a Random Access Memory (RAM) **1014**, Read Only Memory (ROM) **1016**, an I/O adapter **1018** for connecting peripheral devices, such as disk storage units **1020** to the bus **1012**, a user interface adapter **1022** for connecting a keyboard **1024**, a mouse **1026**, a speaker **1028**, a microphone **1032**, and/or other user interface devices, such as a touch screen, a digital camera (not shown), etc., to the bus **1012**, communication adapter **1034** for connecting the workstation to a communication network **1035** (e.g., a data processing network) and a display adapter **1036** for connecting the bus **1012** to a display device **1038**.

In one example, the workstation may have resident thereon an operating system, such as the MICROSOFT® WINDOWS® Operating System (OS), a MAC OSR, a UNIXR OS, etc. In one embodiment, the system **1000** employs a POSIXR based file system. It will be appreciated that other examples may also be implemented on platforms and operating systems other than those mentioned. Such other examples may include operating systems written using JAVAR, XML, C, and/or C++ language, or other programming languages, along with an object oriented programming methodology. Object oriented programming (OOP), which has become increasingly used to develop complex applications, may also be used.

FIG. **11** is a block diagram illustrating a distributed system **1100** for using natural language software to respond to a Boolean question and automatically providing evidence and providing more fine-grained answers to Boolean questions, according to one embodiment. In one embodiment, the system **1100** includes client devices **1110** (e.g., mobile devices, smart devices, computing systems, etc.), a cloud or resource sharing environment **1120** (e.g., a public cloud computing environment, a private cloud computing environment, a data center, etc.), and servers **1130**. In one embodiment, the client devices **1110** are provided with cloud services from the servers **1130** through the cloud or resource sharing environment **1120**.

One or more embodiments may be a system, a method, and/or a computer program product at any possible technical detail level of integration. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present embodiments.

The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory

(ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program instructions for storage in a computer readable storage medium within the respective computing/processing device.

Computer readable program instructions for carrying out operations of the embodiments may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, configuration data for integrated circuitry, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++, or the like, and procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present embodiments.

Aspects of the embodiments are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

These computer readable program instructions may be provided to a processor of a computer, or other programmable data processing apparatus to produce a machine, such

that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function(s). In some alternative implementations, the functions noted in the blocks may occur out of the order noted in the Figures. For example, two blocks shown in succession may, in fact, be accomplished as one step, executed concurrently, substantially concurrently, in a partially or wholly temporally overlapping manner, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

References in the claims to an element in the singular is not intended to mean "one and only" unless explicitly so stated, but rather "one or more." All structural and functional equivalents to the elements of the above-described exemplary embodiment that are currently known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the present claims. No claim element herein is to be construed under the provisions of 35 U.S.C. section 112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or "step for."

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the embodiments. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present embodiments has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the embodiments. The embodiment was chosen and described in order to best explain the principles of the embodiments and the practical application, and to enable others of ordinary skill in the art to understand the embodiments for various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. A computer-implemented method of using natural language software to respond to a Boolean question, the method comprising:

receiving a question and at least one passage;

classifying the question as a Boolean type of question;

generating evidence from the at least one passage to answer the Boolean type of question;

generating a response to the Boolean type of question using the generated evidence, wherein the response is a fine-grained Boolean type of answer labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer, or a scaled type of answer; and

providing the generated evidence that supports the response to the Boolean type of question.

2. The method of claim **1**, wherein the classifying employs a question type classifier to determine the question type.

3. The method of claim **1**, wherein the generated evidence that supports the response is indicated by demarcating the generated evidence in the at least one passage.

4. The method of claim **1**, wherein the generated evidence comprises text-based evidence in one or more languages.

5. A computer program product for using natural language software to respond to a Boolean question, the computer program product comprising a computer readable storage medium having program instructions embodied therewith, the program instructions executable by a processor to cause the processor to:

receive a question and at least one passage;

classify the question as a Boolean type of question;

generate evidence from the at least one passage to answer the Boolean type of question;

generate a response to the Boolean type of question using the generated evidence, wherein the response is a fine-grained Boolean type of answer labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer, or a scaled type of answer; and

provide the generated evidence that supports the response to the Boolean type of question.

6. The computer program product of claim **5**, wherein the classifying employs a question type classifier to determine the question type.

7. The computer program product of claim **5**, wherein the generated evidence that supports the response is indicated by demarcating the generated evidence in the at least one passage.

8. The computer program product of claim **5**, wherein the generated evidence comprises text-based evidence in one or more languages.

9. An apparatus comprising:

a memory configured to store instructions; and

a processor configured to execute the instructions to:

receive a question and at least one passage;

classify the question as a Boolean type of question;

generate evidence from the at least one passage to the Boolean type of question;

generate a response to the Boolean type of question using the generated evidence, wherein the response is a fine-grained Boolean type of answer labeled as a weak-No answer, a weak-Yes answer, both Yes and No answer, or a scaled type of answer; and

provide the generated evidence that supports the response to the Boolean type of question.

10. The apparatus of claim **9**, wherein the classifying employs a question type classifier to determine the question type.

11. The apparatus of claim **9**, wherein the generated evidence that supports the response is indicated by demarcating the generated evidence in the at least one passage, and the generated evidence comprises text-based evidence in one or more languages.

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